PHYS 102-Concepts of Physics II-Spring 2007
Solutions to Homework #3
100 points possible

1. (20 points)

(a) I did this twice and got 3 cm and 4 cm, which convert to 0.03 m and 0.04 m
(b) The average is 0.035 m. Using $H = 1/2\ g\ t^2$, this gives a "reaction time" of about 0.085 seconds (or 85 milliseconds).
(c) Light travels at 3×10^8 m/s, so in 85 milliseconds it travels 2.55×10^7 meters. There are 1609.3 meters per mile, so this translates to about 15,850 miles. Your answer of course may differ since your reaction time may differ.
(d) In 100th of a second (0.01 seconds), light travels 3 million meters, which is about 1864 miles. According to the measurements given, this is about 78% of the way from central Virginia to San Francisco, which puts the leading edge of the light beam in central Utah. (You must include the map for full credit.)

2. (10 points)
The question reads "What evidence is there that the medium that carries light waves is not air?" For full credit you should add something beyond the answer in the book which is "Light travels through outer space where there is no air."

To elaborate on the book's answer, the reason we can see the sun is that the (visible) light from it travels through the vacuum of space. To go further, the infrared light from the sun is what makes our skin feel warm when standing in direct sun. Also, the ultraviolet (UV) light from the sun gives us a sunburn, so all of those show that electromagnetic waves travel through a vacuum.

Also, satellites are outside the atmosphere, and they send signals (for cable TV, GPS system, etc) which are electromagnetic waves. Also, radio waves are used to communicate with the International Space Station. Those waves must pass through the vacuum of space. So there are many examples.

3. (10 points) Since it takes light 20 minutes to travel from Mars to Earth, that limits the speed of communication. If you use radio waves, the person on Mars would have to wait, after sending a few words, at least 40 minutes for a reply. (20 minutes for the signal to reach Earth, a few seconds for the reply to be stated, then 20 minutes for the reply to reach Mars). Using a telescope would not help at all, because it would take the visual signals (i.e. visible light) just as long to travel. (Using sound—which would travel vastly slower in any case—is not possible because sound won't propagate through the vacuum of space.)

4. (10 points) The question reads "You do not get a sunburn, even on a sunny day, if you are behind glass. Why?" It is the ultraviolet (UV) light from the sun which causes sunburn. If you don't feel the effect when behind glass, it must be because the glass is blocking the transmission of the UV. (This is helpful, for example, because you can prevent sunburn when riding in a car just by rolling up the windows.)

5. (10 points) If you viewed or attempted to photograph Earth's dark side (i.e. the side which at that moment is not illuminated by the sun), you would only see an image with infrared-sensitive film. That's because the Earth remains warm or hot even during the night, so it still emits infrared radiation. You won't see any significant amounts of visible light or UV from the Earth's dark side.

6. (25 points) EM waves problem.

   (a) On a warm day in the shade, your face is being heated by the warm air surrounding it. A piece of cardboard won't impede that air flow. But, near a fire or lamp, your face is being heated by the infrared radiation (electromagnetic waves) emitted by the fire or lamp. Blocking those waves can make your face instantly cooler.

   (b) The electron has an energy of 70,000 electron-volts, which (using the conversion 1 eV = 1.6×10^{-19} Joules) equals 1.12×10^{-14} Joules. Then use E = hf, or f = E/h = (1.12×10^{-14} Joules)/(6.6×10^{-34} Joules x seconds) giving **f = 1.7×10^{19} Hz**. Then, wavelength = (speed of light)/(frequency) = **1.8×10^{-11} meters**. Comparing either of these to the chart shows that these are X-ray photons, and quite high energy ones at that.

   (c) Using the formula given on the assignment, the peak wavelength for the sun (Temp. = 10,000 F) is 5×10^{-7} meters, or 500 nanometers. This makes sense, because this is near the middle of the visible spectrum, and we know the sun emits a lot of visible light (and also a lot of IR and UV). Also, this number agrees with the peak of the graph on page 200.

      For the human body (Temp. = 90 F), the computed peak wavelength is about 9.5×10^{-6} meters. If you round this to 10^{-5} meters, it's easy to see from the chart on page 196 that this is in the infrared region. This makes sense because the human body emits a lot of IR.

7. (15 points)

   (a) WSB in Atlanta is 750 AM, which means 750 kHz. On the chart this is shown as "**Broadcasting (AM Radio)**."
   (b) WBCN in Boston is 104.1 FM, which means 104.1 MHz. On the chart this is shown as "**Broadcasting (FM Radio)**."
   (c) (Cell phone frequencies 866 to 869 MHz). On the chart this is shown as "**Land Mobile**".
   (d) (GPS frequency 1575 MHz). This is labelled as "**Aeronautical Radionavigation**" and "**Radionavigation Satellite (Space to Earth)**."